

Kentucky Geological Survey

228 Mining & Mineral
Resources Bldg.
University of Kentucky
Lexington, KY
40506-0107
859.257.5500
fax 859.257.1147
www.uky.edu/KGS

James Cobb, State
Geologist and
Director
John Kiefer, Assistant
State Geologist
Carol Ruthven, Editor,
Kentucky Geology

Our mission is to
increase knowledge and
understanding of the
mineral, energy, and
water resources,
geologic hazards, and
geology of Kentucky for
the benefit of the
Commonwealth and
Nation.

In this issue

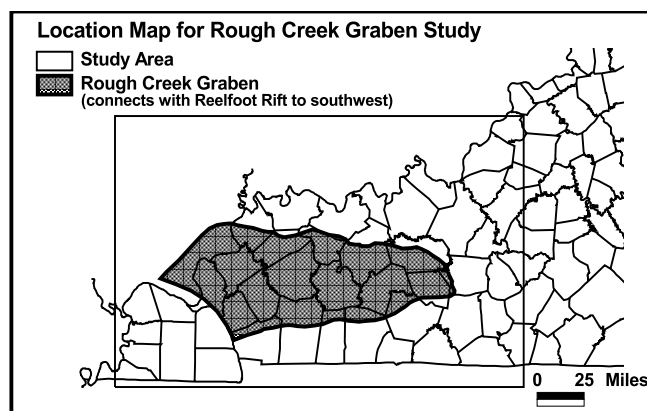
New natural gas research planned	1
KGS Digital Geologic Mapping Program	1
Quaternary mapping in Kentucky, Indiana, and Illinois	1
Geology, GIS, and planning	2
Land-use planning maps	2
In Focus: Reducing global warming by storing CO ₂ beneath the earth's surface	Insert
Spotlight on new publications	3
Technology transfer	3
KGS annual meeting	3
Calendar of events	4

Potential in the Rough Creek Graben— New natural gas research planned

The Kentucky Geological Survey is planning a new research consortium to study the deep natural gas potential of the Rough Creek Graben in western Kentucky. The project will focus on the Cambrian (Rome/Eau Claire) and possibly Precambrian rocks in the graben and surrounding areas in Kentucky and southern Illinois. This research is dependent on funding from the U.S. Department of Energy and joint industry participation. The project would be structured similarly to the recently completed Rome Trough Consortium project in eastern Kentucky, Ohio, and West Virginia. Final products will include:

- ◆ Structural and stratigraphic well-log cross sections
- ◆ Digitized well logs
- ◆ Interpretation of available seismic data
- ◆ Structure and isopach maps of potential reservoir intervals and basement
- ◆ Core descriptions
- ◆ Exploration models and final report

Companies interested in participating in this project are encouraged to contact **Dave Harris** at 859.257.5500 ext. 173 (e-mail dcharris@uky.edu) or **Jim Drahovzal** at 859.257.5500 ext. 175 (e-mail drahovzal@uky.edu). ❖



Funding renewed for 2004— KGS Digital Geologic Mapping Program

Warren Anderson and **Drew Andrews** of the Geospatial Analysis Section of KGS received a 1-year, \$245,350 grant from the U.S. Geological Survey for the 2004 continuation of the USGS STATEMAP Program. The funding will be used to convert geologic maps for Kentucky into digital format and to conduct new mapping of surficial materials along the Ohio River in western Kentucky.

This is the ninth consecutive year of funding from the USGS. Since 1996 the Digital Geologic Mapping Program has generated total project awards of \$1.6 million.

The digital geologic map information is important for the long-term growth and development of the Commonwealth. For more information, contact **Warren Anderson**, principal investigator of the Digital Geologic Mapping Program, at 859.257.5500 ext. 151 or by e-mail at wanderson@uky.edu. ❖

Disaster preparedness for Greater Evansville area— Quaternary mapping in Kentucky, Indiana, and Illinois

The Western Kentucky Office of the Kentucky Geological Survey and the Disaster Prepared Communities Corporation of South-

western Indiana hosted a tri-state Quaternary mapping conference in Evansville, Ind., November 18–19. The purpose of the conference was to

review the current understanding of the Quaternary for the Greater Evansville area and to lay the groundwork for

(continued on page 4)

Director's Desk



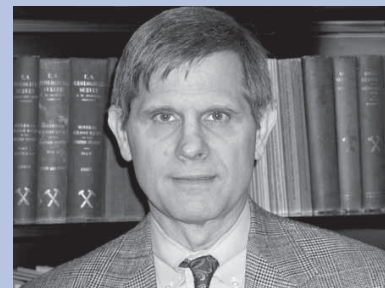
The future development of coalbed methane resources and implementation of carbon sequestration operations in Kentucky offer the prospect of significant economic and environmental benefits for the Commonwealth. During the past 3 years, we have been leaders in the development of carbon sequestration technology and assessment of coalbed methane potential in Kentucky.

The production of coal, along with the related generation of electricity from coal-fired power plants, has been a mainstay of Kentucky's economy for decades. Although vast undeveloped reserves of coal remain in Kentucky, developing all of these reserves may not be economic or technically feasible at existing market prices for coal. There is tremendous economic potential on the horizon, however, to use our coal resources to develop coalbed methane and for carbon sequestration operations.

Coalbed methane is a gas that occurs in association with coal. When coal is formed underground over millions of years, large amounts of gas (mainly methane) are produced—more gas than the coal can hold. Some of this

gas escapes into other rocks or into the atmosphere, but some of it remains in the coal. Assessing the coalbed methane resource in the Eastern and Western Kentucky Coal Fields is essential if we are to understand the economic potential for coalbed methane production. With the support of Federal and State agencies, KGS has begun a program to assess the coalbed methane potential of various coal beds in western Kentucky. We are also seeking Federal and State support to supplement industry support that we have secured for a similar resource assessment in eastern Kentucky.

Carbon sequestration refers to a process of capturing and safely storing in underground reservoirs carbon dioxide (CO₂) from emission stacks of coal-fired power plants and other industrial plants. It has two major benefits. Reduction of CO₂ in the atmosphere can help address problems associated with global warming. Injection of CO₂ into oil reserves can enhance the recovery of oil; and the injection of CO₂ into coal seams can produce coalbed methane.



We are now engaged in detailed assessments of specific sites for potential carbon sequestration in Kentucky. We intend to test some of these sites to determine if they might provide safe, long-term CO₂ storage.

The development of coalbed methane resources and implementation of carbon sequestration operations provide an opportunity to use state-of-the-art technology and geologic research to maximize the future use of our rich endowment of energy resources.

James C. Carey

Geology, GIS, and planning

A 1-day workshop to discuss technical issues, research expertise, and online data and mapping resources for geology, GIS, and planning was hosted by KGS in Lexington on November 19. Speakers from KGS, the Natural Resources Conservation Service, and the Northern Kentucky Area Planning Commission discussed soils and geology, building on karst terrain, geologic hazards, geologic maps and GIS, and GIS and planning.

The PowerPoint presentations from the workshop are available on the News and Announcements section of the KGS Web site (www.uky.edu/kgs). The workshop was followed by a 2-day training class, "Introduction to ArcView

GIS 3.x," taught by Dan Carey, an ESRI-certified instructor at KGS.

A similar workshop may be hosted by KGS in the spring of 2004. If you are interested, please contact **Carol Ruthven** at 859.257.5500 ext. 128 or by e-mail at cruthven@uky.edu. ❖

Generalized geologic maps for land-use planning

As economic growth continues in Kentucky, there is an increasing need for a better understanding of the potential impact that local geology can have on land use. KGS is cooperating with the U.S. Department of Agriculture–Natural Resources Conservation Service to produce generalized geologic maps that can be used for land-use

planning. The maps provide information on how the underlying rock in an area affects excavation and foundations, onsite wastewater treatment systems, residential and industrial developments, highway and street construction, and pond and reservoir construction. Photographs of sites in the area illustrate the geologic concepts discussed in the text.

These maps have been published for six counties (Butler, Edmonson, Jessamine, Scott, Warren, and Woodford), Lexington and Fayette County, and the Berea 7.5-minute quadrangle. They are available on the KGS Web site at www.uky.edu/KGS/pubs/lop.htm. For more information, contact **Dan Carey** at 859.257.5500 ext. 157 or by e-mail at carey@uky.edu. ❖

Reducing Global Warming by Storing Carbon Dioxide beneath the Earth's Surface—Exploring the Prospects for Carbon Sequestration

Carol L. Ruthven
February 2004

Carbon dioxide emissions and global warming

Hydrocarbons (oil, natural gas, and coal) are expected to be the primary source of energy in the United States for at least the next 50 years. There is mounting scientific evidence that increasing concentrations of carbon dioxide (CO₂) are contributing to global warming. Carbon dioxide is released to the atmosphere when carbon-containing fuels such as oil, natural gas, and coal are burned. This problem is compounded by carbon emissions from forest fires and forests burned to clear land.

Carbon dioxide increases the capacity of the atmosphere to trap heat (the “greenhouse effect”) and this contributes to global warming. Daily activities by all of us add to the problem—CO₂ is released in emissions from vehicles, large industrial complexes, and power plants.

In 1988, the World Meteorological Organization and the United Nations Environmental Programme established the Intergovernmental Panel on Climate Change (www.ipcc.ch) to assess scientific, technical, and socioeconomic factors relevant for understanding climate change. In its 2001 report, the IPCC concluded that the atmospheric concentration of CO₂ increased 31 percent from 280 parts per million in 1750 to 367 ppm in 1999. It also concluded that the global average surface temperature (the average of near-surface air temperature over land and sea surface temperature) increased over the 20th century by about 0.6 degrees Celsius. The IPCC reported, “Globally, it is very likely that the 1990s was the warmest decade and 1998 the warmest year in the instrumental record, since 1861.” (www.grida.no/climate/ipcc_tar/wg1/016.htm)

In a December 2003 policy statement, “Human Impacts on Climate,” the Council of the American Geophysical Union said that “it is virtually certain that increasing atmospheric concentrations of carbon dioxide and other greenhouse gases will cause global surface climate to be warmer.” (www.agu.org/sci_soc/policy/

climate_change_position.html). The environmental impact of global warming is not well understood but diverse and widespread; it includes glaciers melting more rapidly than in the past, increased loss of forests damaged by pests (e.g., budworm and pine beetle), and earlier spring weather and hotter summer weather in places around the globe. Although roughly half of the CO₂ released in the atmosphere is absorbed by plants and trees in forests as part of photosynthesis or absorbed by oceans, a significant amount of CO₂ remains in the atmosphere.

Carbon sequestration technology

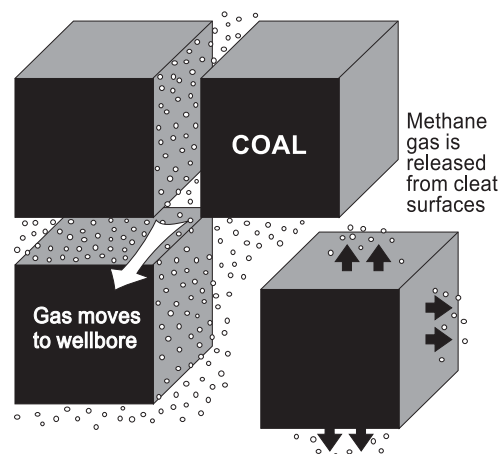
Carbon sequestration research is focused on finding ways to capture and safely store CO₂ from emission stacks of coal-fired power plants and other industrial plants. Carbon dioxide can be captured from a power plant's flue-gas stream (i.e., the gas produced as a byproduct of burning coal). The flue gas can be “scrubbed” or “cleaned” to remove the CO₂. The CO₂ can be converted into a concentrated stream, pressurized until it becomes a liquid, and then transported by pipeline to a site for injection into underground reservoirs for long-term storage.

In projects across the nation, geologists are evaluating the potential for sequestering CO₂ in traditional and unconventional oil and gas reservoirs, uneconomic coal seams, and saline aquifers. They are also evaluating potential economic benefits of enhanced production of oil and coalbed methane that might result from carbon sequestration operations.

During the past 20 years, CO₂ has been injected into mature oil fields, particularly in Texas, Colorado,

Wyoming, and New Mexico, to produce oil remaining in reservoir pores after primary production is complete. The injected CO₂ affects chemical interactions among the reservoir rock and oil. When CO₂ mixes with the remaining oil, it can expand its volume and reduce its viscosity (thickness), making it easier to pump to the surface. This process is referred to as “enhanced oil recovery” or “EOR.”

The success of EOR operations has spurred scientists to investigate coal seams to determine if they may



also absorb CO₂ and displace methane as a recoverable product to enhance natural gas production.

Research at KGS

Geologists at KGS are providing regional leadership in carbon sequestration research. With current funding of more than \$680,000 from the U.S. Department of Energy and industry partners, KGS geologists are active in numerous carbon sequestration research projects.

MIDCARB. The Survey's involvement in carbon sequestration research began in 2000 with the Midcontinent Interactive Digital Atlas and Relational Database (MIDCARB) project (www.midcarb.org). For the past 3

years, KGS has cooperated with the geological surveys of Illinois, Indiana, Kansas, and Ohio to evaluate the potential for carbon sequestration in the Midwest. The Ohio River Valley has the largest concentration of power plants in the nation.

The MIDCARB team built an integrated database of information and maps that could be used by decision-makers in the public and private sectors to evaluate options for the future management of CO₂ emissions. This research has been timely—a question being debated publicly is whether Congress should begin to regulate CO₂ emissions from coal-fired power plants.

The five-state MIDCARB team identified the locations of large sources of CO₂ emissions, such as coal-fired power plants, petroleum refineries, cement plants, and other large industrial complexes in the Midwest. They also identified potential sites for storage of CO₂, including oil and gas reservoirs, coal beds, organic-rich shales, and saline aquifers. An Internet mapping site was then constructed to link geologic data and maps from the five states and allow decision-makers to evaluate alternative carbon sequestration options.

In 2004, the MIDCARB project is being expanded to include geologic data and maps for 33 states. The data and maps are being compiled by seven regional sequestration partnerships. KGS is participating in two of the seven partnerships (the Midwest and Appalachia partnerships discussed below). KGS is also helping West Virginia and Pennsylvania to add information about CO₂ sources and potential geologic sites for carbon sequestration in their states. KGS received \$100,000 from DOE for the 1-year extension of the MIDCARB project.

Carbon sequestration in the Midwest and Appalachia. Building on the expertise and data we acquired in the MIDCARB project, KGS is researching in greater

detail the prospects for carbon sequestration in the Midwest and Appalachia. KGS geologists are studying the geologic framework of the regions in order to get a better understanding of CO₂ storage options. They are also including geographic information system (GIS) data to identify pipelines

The MIDCARB Internet mapping site was the first system developed in the nation for the U.S. Department of Energy that successfully linked and integrated geologic maps and data from multiple states.

and other infrastructure that could be used to transport CO₂ from emission sources to storage sites. The goal is to eventually drill wells to demonstrate the feasibility of sequestering CO₂ in various geologic storage sites.

In the study of the Midwest region, KGS is collaborating with the Illinois and Indiana geological surveys. KGS received a grant of \$200,842 from DOE for this research.

In the study of the Appalachian region, KGS is collaborating with Battelle National Energy Technology Laboratory; the geological surveys of Indiana, Ohio, Pennsylvania, and West Virginia; Ohio State University; Pennsylvania State University; Purdue University; West Virginia University; and seven energy companies. DOE provided KGS with a grant of \$50,066 for this 2-year project.

Devonian black shale. Researchers at KGS are also investigating the potential to dispose of CO₂ by sequestering it in black shales in Kentucky. In this 3-year project (July 1, 2002–June 30, 2005), funded with a DOE grant of \$532,966, KGS is collaborating with scientists at the University of British Columbia and DOE's National Energy Technology Laboratory.

Devonian black shales are organic-rich rocks that serve as a source and trap for natural gas. Most of the natural gas is adsorbed on clay and kerogen (fossilized insoluble organic material) surfaces; this is similar to the way in which methane gas is stored in coal beds. It has been demonstrated that in high-rank coal, on average, CO₂ is preferentially adsorbed, displacing methane at a ratio of two for one. In other words, approximately two CO₂ molecules will adsorb to every one methane molecule released. In a similar way, black shales may desorb methane in the presence of adsorbing CO₂. If this is the case, and preliminary research is indicating that it is, black shales may be an excellent trap for storing CO₂ and it could have the added economic incentive of enhancing natural gas production.

Benefits of carbon sequestration

The potential benefits of carbon sequestration are numerous. It could provide revenue for the petroleum industry from enhanced production of oil and natural gas. It could allow our nation to continue to use its abundant and inexpensive coal resources to generate electricity; this would benefit coal producers, as well as electricity consumers. It could also provide a bridge to ease the transition away from dependence on fossil fuels toward increased reliance on renewable fuels, energy efficiency, and energy conservation in this century.

For information about carbon sequestration research at KGS, contact **Jim Drahovzal**, head of the Energy and Minerals Section, at 859.257.5500 (ext. 175) or send an e-mail to drahovzal@uky.edu. Additional information about carbon sequestration research projects is found on the KGS Web site at www.uky.edu/kgs.

Spotlight on new publications

Water well and spring maps

The Kentucky Groundwater Data Repository has a wealth of data useful for environmental consultants, engineers, and citizens. Since the spring of 2002, **Bart Davidson**, manager of the repository, has compiled 23 maps (1:100,000 scale) showing the distribution and location of water wells and springs in the following 30 x 60 minute quadrangles:

- Beaver Dam
- Bowling Green
- Campbellsville
- Corbin
- Elizabethtown
- Evansville
- Falmouth-Cincinnati-Madison
- Harrodsburg
- Hazard
- Hopkinsville
- Huntington
- Irvine
- Lexington
- Louisville
- Madisonville
- Morehead
- Murray
- Paducah
- Pikeville
- Somerset
- Tell City
- Tompkinsville
- Williamson

Each map, which covers an area of approximately 31 by 54 miles, displays the locations of springs and four types of water wells (domestic or private, industrial, public, and monitoring). Detailed information about the wells and springs identified on the maps is available from the **Kentucky Groundwater Data Repository**, which is maintained by KGS. Each map is available as a PDF file at www.uky.edu/KGS/pubs/lop.htm, or can be purchased from the Public Information Center. For more information, contact Davidson at 859.257.5500 ext. 162 or by e-mail at bdavidson@uky.edu. ❖

Mark your calendar!

The 44th annual meeting of the Kentucky Geological Survey will be held on Friday, April 30. Forthcoming details of the technical program will be posted on the KGS Web site at www.uky.edu/kgs. ❖



New GIS data available on KGS Web site

Several new data sets are available in the GIS data library on the KGS Web site (www.uky.edu/KGS/gis/mapimages.html). The new data sets include wetlands maps, landslide potential maps, and mapped sinkholes.

The wetlands maps, produced by the U.S. Fish and Wildlife Service, show categorized wetland areas on a 7.5-minute topographic base. A chart that explains the map symbols, "Key to Wetlands Symbols," is available as a PDF file (kgsweb.uky.edu/download/water/wetlandskey.pdf). GIS data organized by county are also available at www.uky.edu/KGS/gis/hydro.html.

The landslide potential maps, produced by the U.S. Geological Survey, depict generalized slope-stability conditions at the time of field checking (1977–79). They are available for most of southeastern and south-central Kentucky. Mapped units depict the dominant stability conditions in delineated areas. These are preliminary maps and are suitable for general planning purposes only.

The wetlands and landslide maps were scanned in MrSid format and georeferenced in the Kentucky Single Zone coordinate system. Georeferencing allows users to view the maps with other similarly referenced data in GIS or CAD software.

KGS has also added the capability to view and download images of 7.5-minute geologic quadrangle and 7.5-minute topographic maps, georeferenced in the Kentucky State Plane Single Zone projection.

These products can be searched for on the KGS Web site in two ways. If you are seeking a number of adjacent maps, the following links provide an index map on which quadrangles can be selected by state tile codes:

- Wetlands maps: www.uky.edu/KGS/gis/wetlands/index.html
- Landslide maps: www.uky.edu/KGS/gis/landslide/index.html
- 7.5-minute geologic quadrangle maps: www.uky.edu/KGS/gis/gqmaps/index.html
- 7.5-minute topographic quadrangle maps: www.uky.edu/KGS/gis/krgweb/index.html

Alternatively, if you are looking for a particular quadrangle by name, you can search for these maps from the KGS online list of publications at www.uky.edu/KGS/pubs/lop.htm.

Mapped sinkhole data, compiled by KGS and the Kentucky Speleological Survey, Inc., were delineated from the outermost closed depression contour on USGS 1:24,000-scale digital topographic maps. These are vector data in ESRI shapefile format, in latitude and longitude coordinates (NAD83 datum). The files and associated metadata are available at www.uky.edu/KGS/gis/sinkpick.htm.

For more information, contact **Dan Carey** at 859.257.5500 ext. 157 or by e-mail at carey@uky.edu. ❖

New Internet mapping location tool

A new Internet mapping location tool, ArcIMS Geographic Query Tool, allows you to enter geographic information such as county, quadrangle, town, or coordinates (in any datum and projection) and will open the ArcIMS site you are interested in (from the pull-down list). This tool, which can be found at kgsweb.uky.edu/arcimsSearch.asp, will work with any IMS site that is in Kentucky State Plane Single Zone projection. If you would like your ArcIMS site added to the list (if it is in Single Zone), please contact **Doug Curl** at 859.257.5500 ext. 140 or send an e-mail to doug@uky.edu. ❖

KGS mailing list

Would you like to receive the KGS newsletter and announcements of meetings and new publications? Please call us at 859.257.5500 ext. 128 or send an e-mail message to **Carol Ruthven** at cruthven@uky.edu—simply type “Electronic-

Mailing List Addition” in the subject line of your message, type your mailing address and phone and fax number in the message—and we will include your name and address in our mailing list. ❖

Calendar of events

- ♦ **April 18–21:** AAPG annual meeting, Dallas, Tex., www.aapg.org/meetings/dallas04
- ♦ **April 30:** Kentucky Geological Survey 44th annual meeting
- ♦ **May 15:** Spring field trip and awards banquet, Kentucky Section of the American Institute of Professional Geologists, Kentucky Dam Village State Resort Park, Gilbertsville, Ky., www.professionalgeologist.org
- ♦ **October 3–6:** Eastern Section AAPG, annual meeting, Columbus, Ohio, www.ohiodnr.com/geosurvey/aapg04.htm
- ♦ **October 10–16:** Earth Science Week 2004, “Living on a Restless Earth,” www.earthsciweek.org
- ♦ **October 21–23:** Kentucky Society of Professional Geologists annual fall field conference
- ♦ **November 7–10:** Geological Society of America annual meeting, Denver, Colo., www.geosociety.org/meetings/2004
- ♦ **Nov. 17:** GIS Day, www.gisday.com ❖

(“Quaternary mapping,” continued from page 1)

organizing a cooperative effort for geologically mapping these sediments. The participants discussed the mapping requirements necessary to support the detailed assessment of earthquake hazards of a seven-quadrangle region.

The conference included field trip stops along the Ohio River Valley in Henderson, Evansville, and Owensboro and paleoliquifaction features in the Wabash River Valley north of Evansville. Attendees included researchers and representatives from the Central United States Earthquake Consortium–State

Geologists, the U.S. Geological Survey, the Evansville Building Commission, the Indiana Geological Survey, the Illinois State Geological Survey, the Kentucky Geological Survey, the University of Kentucky, Purdue University, the University of Southern Indiana, and Western Michigan University. For more information, contact **Dave Williams**, manager of the Western Kentucky Office, at 270.827.3414 or by e-mail at williams@uky.edu. ❖

Kentucky Geological Survey
228 Mining & Mineral Resources Bldg.
University of Kentucky
Lexington, KY 40506-0107

Address service requested

Nonprofit Organization U.S. Postage PAID Lexington, KY Permit No. 51
--